Glacial geomorphological research at Mýrdalsjökull, Iceland, 1977-86. I: the northern margin

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The lithostratigraphic divisions of the glacier forefield are tentatively interpreted as responses to a glacier advance about the middle of the 18th century, a following retreat, and oscillations have been succeeded by a continuous retreat in the present century. Most recently the glacier is re-advancing. During periods of deglaciation the marginal and the exposed subglacial landsystem were modified by glaciofluvial processes in the direction of a proglacial landsystem. Subsequent flows of ice across the area have led to deposition of lodgement tills and renewal of the subglacial landsystem.

Keywords: *Glacial geomorphology, Till, Neoglacial stratigraphy, Iceland.*

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In 1977 a field study was started on glacial process distribution, land form patterns, vertical lithofacies sequences and lateral lithofacies relationships in the Mýrdalsjökull area, South Iceland. It is a one-sided approach of the general study of glacial phenomena, because the Mýrdalsjökull area only makes up a small sample of the depositional and environmental complexity existing in response to thermal and dynamic regimes of modern lowland glaciers. The field research was carried out during the 1977, 1979, 1982, 1984, and 1986 seasons, and some of the preliminary results have been published in various papers (Humlum, 1981a, 1981b, 1983, 1985a, 1985b; Krüger, 1979, 1982, 1983, 1984, 1985a, 1985b, 1987a, 1987b, 1988; Krüger and Humlum, 1980, 1981; Krüger and Thomsen, 1981, 1984).

FIELD AREA

Mýrdalsjökull is a small, temperate ice cap situated about 150 km east-south-east of Reykjavik. The ice cap, which covers the volcanic Katla massif, has a surface area of about 596 km^2 (Björnsson, 1986). Two principal areas were selected for the research work (fig. 1).

(1) The northern part of Mýrdalsjökull is flowing over surfaces of low relief and terminates about 600 m a.s.l. with a continuous glacier front almost 21 km in length.

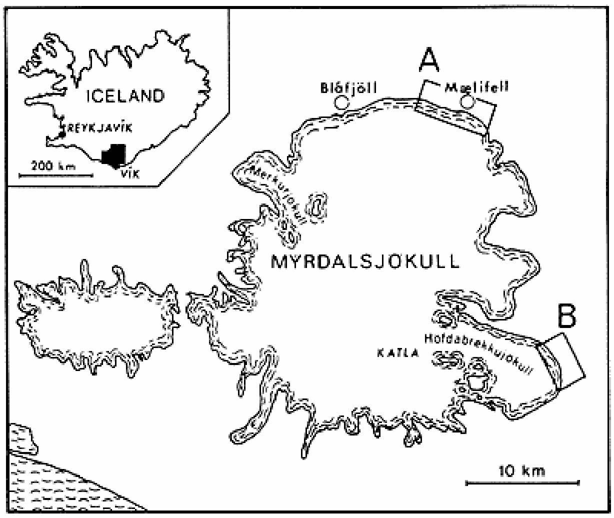

Fig. 1. Location map showing Mýrdalsjökull and the two principal study areas. (A) The northern margin of Mýrdalsjökull. (B) The north-eastern margin of Höfdabrekkujökull.

The glacier forefield consists of unlithified sediments of mainly glacial and glaciofluvial origin, but here and there low ridges and isolated hills belonging to the Palagonite formation break the monotony of the plain, e.g. Mælifell 791 m and Bláfjöll 744 m. In 1977 the northern ice cap margin was retreating across a low-angled, normal slope, and extensive areas of ground moraine were exposed and offered conditions suitable for studying a subglacial landsystem and its transformation in proglacial environments.

(2) The outlet-glacier Höfdabrekkujökull extends from the south-eastern part of the ice cap and spreads out to form a piedmont-lobe. In 1977 a section of the terminal 2-3 km of the glacier snout was debris covered with conditions favouring supraglacial flowage processes and zonal down-wasting.

At present, however, the northern margin of the ice cap is stationary or slightly advancing, and Höfdabrekkujökull is rapidly advancing probably as a response to a general climatic deterioration in Iceland. This evident change of behaviour of the glacier now opens up possibilities of investigating phenomena related to glacier advance across areas of unlithified sediments.

The following is a review of the investigations carried out in the first-named study area, the northern margin of Mýrdalsjökull, during the last 10 years.

THE GLACIER FOREFIELD

In the Mælifell area the glacier forefield is bounded by an ice-marginal landsystem of push-moraine ridges which separate a proglacial landsystem of extensive outwash fans from a subglacial one consisting of fluted ground moraine (fig. 2). The marginal moraine was formed during a glacier advance at the end of the 19th century when many of the Icelandic glaciers were of greater extent (Björnsson, 1979). At present the glacier front is situated 1.2-1.5 km behind the marginal landsystem, and the exposed moraine is increasingly under the influence of proglacial processes.

This lateral landsystem relationship, however, which appears so simple, is not a single pattern developed at one glacial event, but it is a superimposed pattern of landforms sculptured by many glaciations.

The subglacial landsystem

Mode of subglacial deposition

Subglacially working sedimentation processes are not easy to observe. In this instance data on the mechanisms involved in the deposition of basal till was indirectly obtained from the study of the end-products exposed beneath the margin of the retreating glacier in 1977, 1979, and 1982.

The deposited till is a massive, compact, dark-grey matrix-supported sandy till with scattered clasts generally 1-10 cm in size. Granulometric analyses of the matrix (<2 mm) show that clay comprises between 5 and 8 percent, silt 38 and 50 percent and sand constitutes between 44 and 56 percent. Distinctive sedimentary characters include fissility, small-scale deformation of till matrix in front of clasts as well as consistent striation on the surfaces of clasts (Krüger, 1979).

Detailed investigations suggest dynamically active ice as the producer of till and that the predominant mode of deposition follows the frictional model for subglacial sedimentation suggested by Boulton (1975). This model describes the lodgement of individual clasts against a substream of deformable till. Many clasts scattered in the till or embedded in the ground moraine surface show a characteristic stoss-lee shape with a smoothed up-glacier termination and an abruptly truncated, down-glacier termination (Okko, 1955; Boulton, 1978; Krüger, 1979; Sharp, 1982). A large number of these clasts, however, also show a significant modification of their lower surfaces (Krüger, 1984). A generalized picture of the formation of this clast shape by the lodgement process is suggested in fig. 3.

Deposition by lodgement also gives rise to local particle size-sorting resulting from selective transport and deposition of different clast sizes (Boulton, 1975). Probably the pavement of particles 1-15 cm in diameter which were observed melting free from the glacier sole during retreat of the glacier edge in 1977, 1979, and 1982 results from this mechanism (Krüger and Humlum, 1981; Humlum,

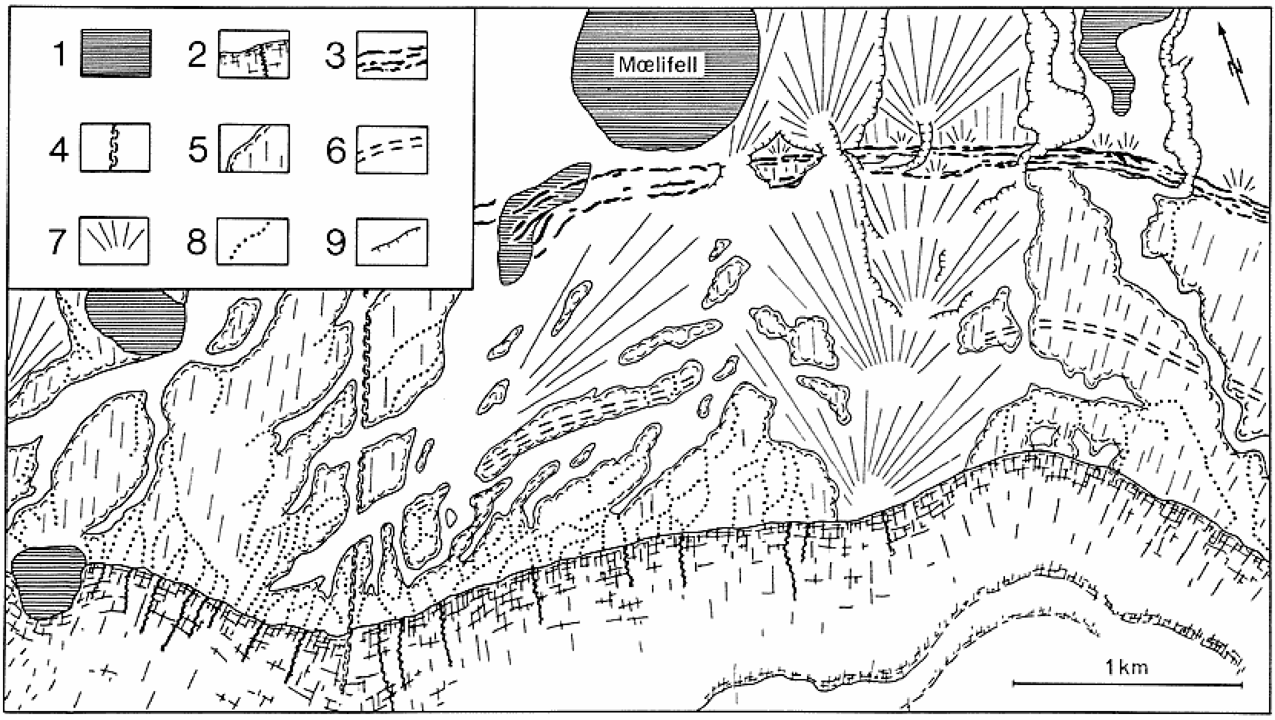

Fig. 2. Geomorphological map of the glacier forefield in the Mælifell area at the northern margin of Mýrdalsjökull. (1) Basalt topography and denudation terrain. (2) Ice. (3) Marginal moraine ridges formed during a glacier advance at the end of the 19th century. (4) Medial moraine. (5) Fluted ground moraine. (6) Overridden ice-marginal moraine ridge. (7) Outwash fan. (8) Meltwater channel cut in ground moraine. (9) Erosion scarp. Mapped on the basis of field observations and aerial photographs taken in 1979.

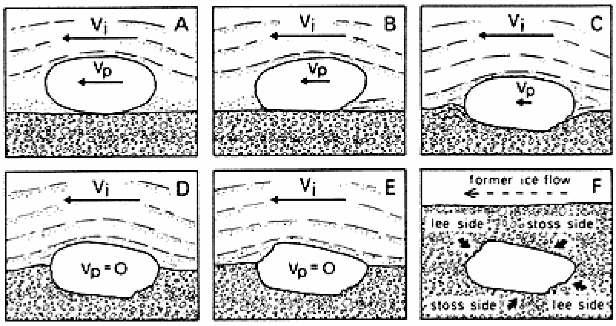

Fig. 3. Formation of double stoss-lee forms by subglacial lodgement. Glacier flow is from right to left. V_i and V_p are the velocities of basal ice and clast in basal transport, respectively. (A) Clast in traction over a bed of already deposited till. (B) Modification of the lower surfaces by movement of the clast over the abrading till bed. (C) Progressive lodgement of the clast against deformable till, which is ploughed up in front of the moving clast. (D) The clast has become firmly lodged. (E) Modification of the upper surfaces by erosion by overriding debris-laden ice. (F) The end product: a clast with double stoss-lee form buried by further lodgement of debris. (After Krüger, 1984)

1981a, 1985a).

Till fabric

Till fabric and local fabric variability in the lodgement till sheet have been studied. 35 samples of 25 clasts (blades and rods) were taken 0.1-0.3 m below the terrain surface. Pebbles less than 0.6 cm long, or with a length:width ratio of less than 3:2, were excluded. The arrangement of 18 selected sampling sites from part of the till plain and a drumlin, is shown in figures 4 and 5, respectively. The till fabric analyses are presented as point- and contour diagrams using the lower hemisphere of the Wulff net. The contouring procedure follows the method suggested by Kamb (1959), which visualizes the statistical significance of apparent orientation peaks. The contours in the diagrams indicate three times the standard deviation from a random distribution. Mean orientations were determined using the symmetry axis of the contour diagrams.

The fabric diagrams indicate a distinct long-axis orientation, and furthermore most diagrams show a low up-glacier dip. Fabric samples from the till plain show mean orientations only deviating 1-12° from the ice flow direction, as revealed by fluted moraine, and between-site variability is moderate and reaches values up to 20° (Krüger and Thomsen, 1981). The fabrics from the drumlin, however, indicate a considerable between-site variability, ranging up to 45° even between samples a few metres apart. The mean orientation for samples taken along the crest of the drumlin deviates only 0-2° from the regional ice-flow direction, whereas the deviation for samples located at the flanks is up to 21°. Furthermore, most fabrics show a characteristic pattern relative to the shape of the drumlin; on the top, the fabric parallels the ice-flow direction,

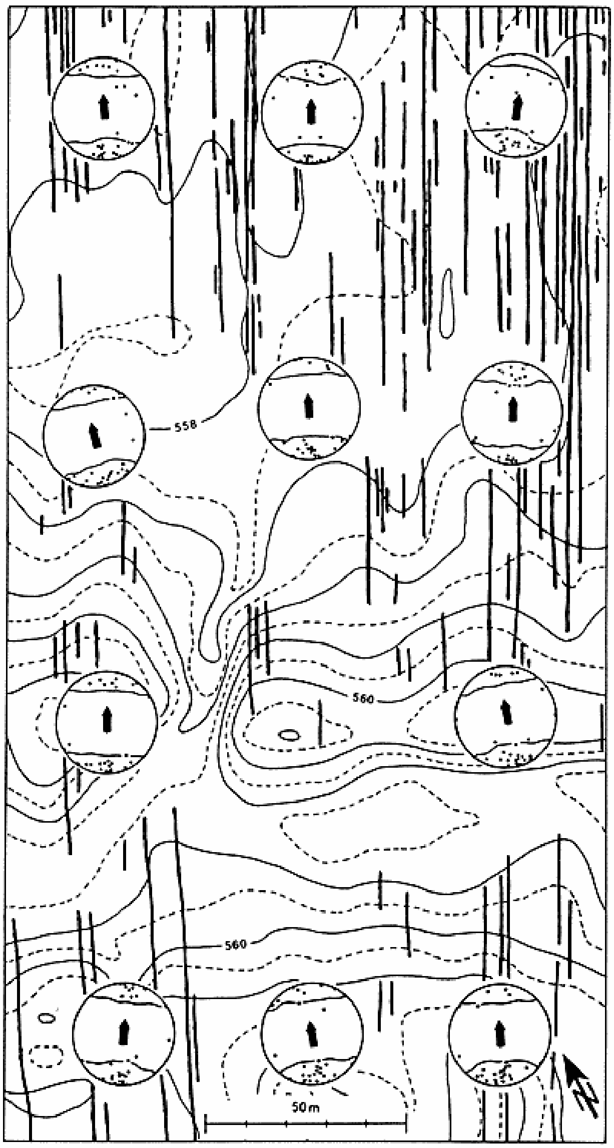

Fig. 4. Detailed geomorphological map of part of the fluted ground moraine located 400-700 m beyond the present glacier margin showing the overridden ice-marginal push-moraine and the till plain in front of it. Contours are at 0.25 m intervals. Elevation related to sea level. The many flutes (thick lines) and the till fabric analyses indicate an ice-flow direction towards the north-north-east during deposition of the till sheet.

whereas it tends to follow the contour direction on the flanks (Krüger, 1983; Krüger and Thomsen, 1981, 1984).

It is concluded that the a-axes clast fabrics of lodgement till typically show strong parallel maxima in alignment with the direction of regional ice flow. Furthermore, most clasts show an up-glacier imbrication.

Geomorphology

A general morphological characteristic demonstrates three types of ground moraine:

1. The low-lying parts are almost flat because they are superimposed on pre-existing till plains or outwash fans.
2. At some places the ground moraine appears as a large-scale transverse smoothed ridge, 2-4 m high and 50-100 m wide, often with a fluted and drumlinized surface (fig. 4). Exposures in the ridge show a core of strongly deformed till and sorted drift discordantly overlain by lodgement till which forms the outer mantle of the ridge (fig. 6). Detailed observations make it reasonable to conclude that the smoothed ridge in the ground moraine is superimposed on a pre-existing marginal push-moraine ridge (Krüger and Humlum, 1980; Krüger and Thomsen, 1984).
3. The high-lying parts of the ground moraine are undulating or drumlinized with a relief rarely exceeding 3-4 m. This type of ground moraine is superimposed on pre-existing morphological elements of ground moraine or outwash fans (Krüger, 1981; Krüger and Thomsen, 1984). In comparison with the description of drumlins in literature (see Menzies, 1979), the drumlins in the forefield of Mýrdalsjökull are extremely small, 20-80 m long, 1-3 m high, and 15-40 m wide. Prior to drumlin formation the drumlin cores were remnants after proglacial meltwater erosion, but during the subsequent flow of ice across the area, the most prominent terrain elements have acted as subglacial obstacles leading to localized till deposition and drumlin formation.

Transformation of the landsystem

Along with the ice front recession the exposed subglacial landsystem becomes more or less affected by marginal and proglacial processes (fig. 7). During winter or early spring small-scale re-advances occur. Along the ice edge an annual moraine ridge, 0.2-0.5 m high, as well as secondary ridges, 0.1-0.2 m high and more broken, are formed by thrusting and folding of the upper part of the lodgement till sheet (see also Sharp, 1984). Small-scale ponding of water between the ridges result in deposition of silt and sand on the exposed lodgement till.

Wherever meltwater is flowing from the glacier surface a network of channels and gaps are cut into the exposed subglacial landsystem, especially in the high-lying parts of the ground moraine south-west of Mælifell (fig. 2). In locations where meltwaters are issuing from subglacial tunnels, or in the low-lying areas the ground moraine is systematically stripped from the glacier forefield and re-deposited as outwash plains, or the till plain is buried by outwash sediments. A branching network of channels and intervening bars, sharp-cut plateaux and terraces of varying age characterizes the morphology of the proximal outwash sediments.

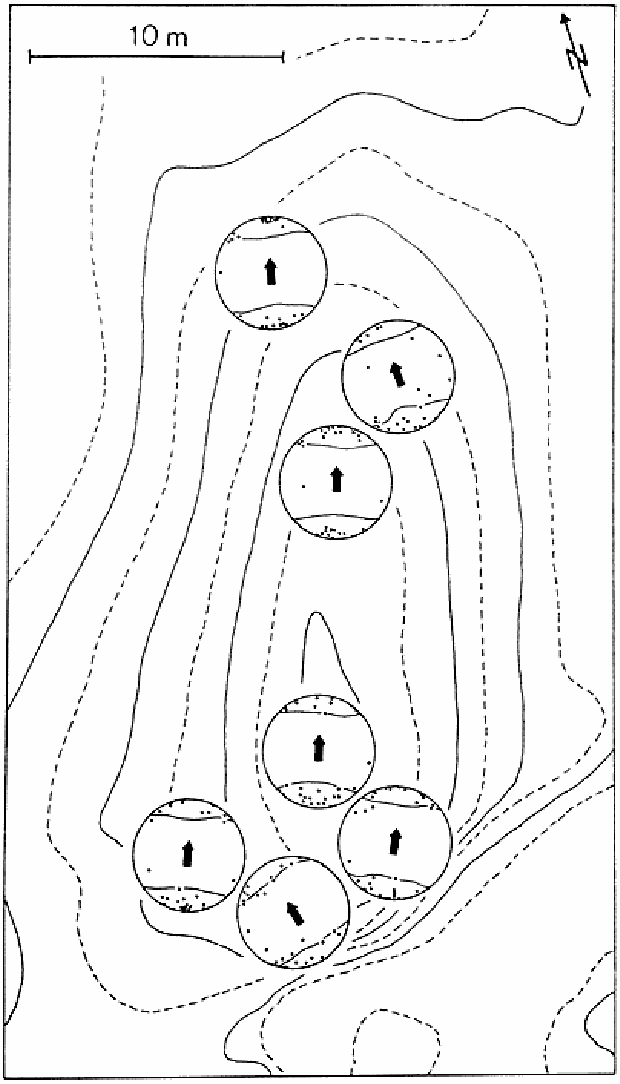

Fig. 5. Map showing the morphology of one of the small drumlins. The southern end of the hill is in a process of destruction by a meltwater stream. Contours are at 0.25 m intervals. The crest line of the drumlin and the till fabric analyses indicate an ice-flow direction towards the north-north-east during deposition of the till sheet.

In such environments large parts of the glacier forefield may undergo a transition from subglacial landsystem through a landscape with poorly developed proglacial forms to mature proglacial landsystem. The extent of the transformation depends on the speed of ice-front retreat and the efficiency of meltwater activity.

Stratigraphy

A generalized picture of the stratigraphy of the ground moraine area south-west of Mælifell showing the major lithostratigraphic divisions is given in fig. 8. Between the

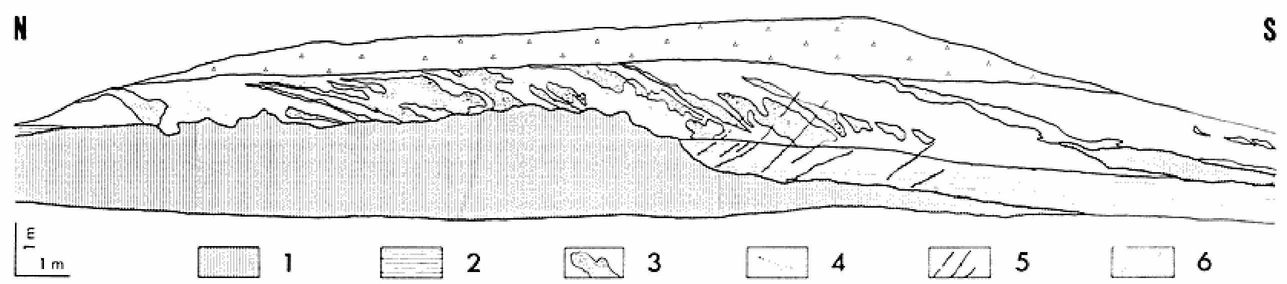

Fig. 6. Exposure in the overridden push-moraine ridge. (1) Scree. (2) Glaciofluvial deposits. (3) Dislocated sorted drift. (4) Thrust planes in till. (5) Tension cracks. (6) Lodgement till. Glacier flow is from right to left. (After Krüger and Humlum, 1980)

glacier front and the overridden push-moraine three till units can be distinguished; only two till units, the upper and lower ones, are found between the overridden moraine ridge and the outermost marginal moraine (Krüger, 1987b). This till sequence is draped, as a layer-cake stratigraphy, over the surface of an extensive body of undisturbed glaciofluvial deposits.

The lower till is a very compact matrix-supported sandy till, 0.1-2.2 m thick, which has a medium-grey colour. In the overridden push-moraine the lower till passes into a zone of structural deformation, indicating an ice push from the south (fig. 6). The middle till is a compact to very compact matrix-supported sandy till, 0.2-0.7 m thick, which has a yellow-grey mottled colour. At most sites lenses and schlieren of sorted sediments are embedded in the till. The succession is capped by an upper till which is a compact dark-grey, matrix-supported sandy till, 0.1-2.0 m thick. This till bed overlies the overridden push-mo-

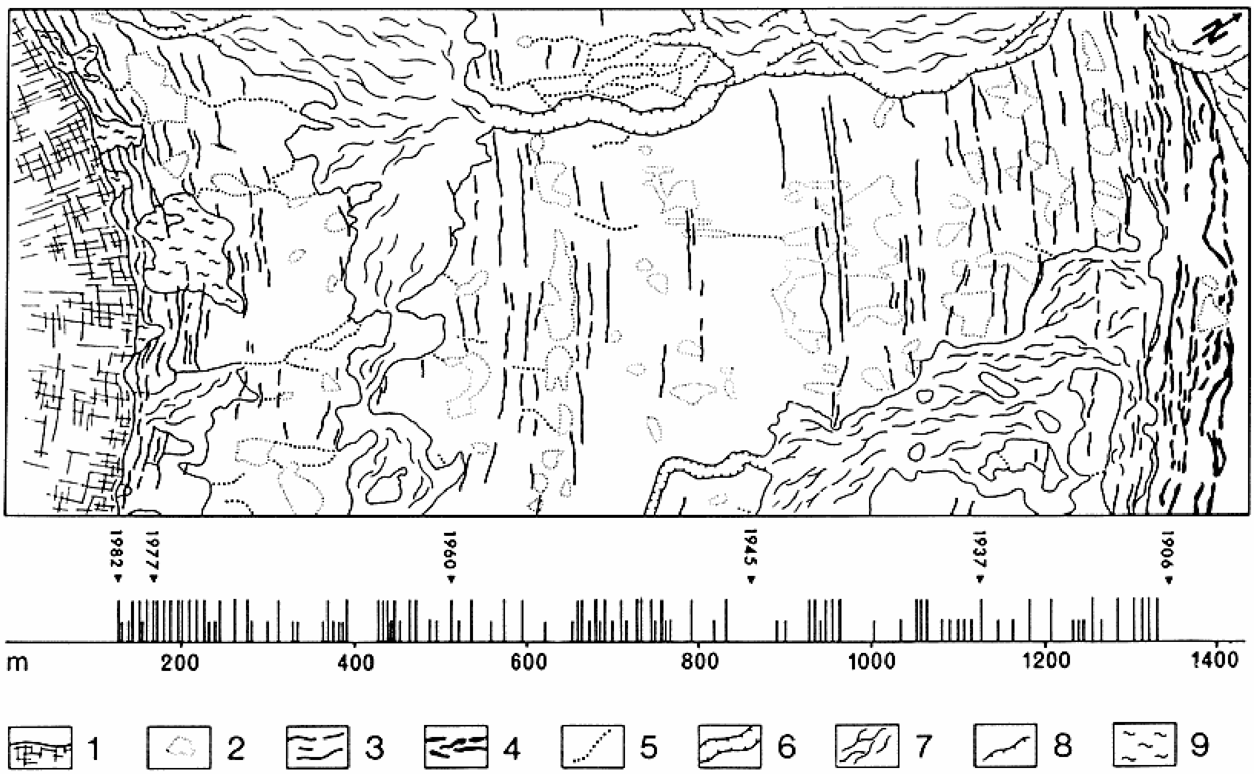

Fig. 7. Detailed geomorphological map of the ground moraine at the northern margin of Mýrdalsjökull showing the transformation in proglacial environment. Below all prominent (long rules) and less prominent (short rules) annual moraine ridges mapped in the field are shown. (1) Ice margin. (2) Ground moraine with downwash basin. (3) Ground moraine with annual moraines. (4) Ice-marginal moraine ridges. (5) Small meltwater channel cut in ground moraine. (6) Large meltwater channel. (7) Braided meltwater channels on outwash plain. (8) Erosion scarp. (9) Lake. Mapped on the basis of field observations and aerial photographs taken in 1979. (After Krüger, 1987b)

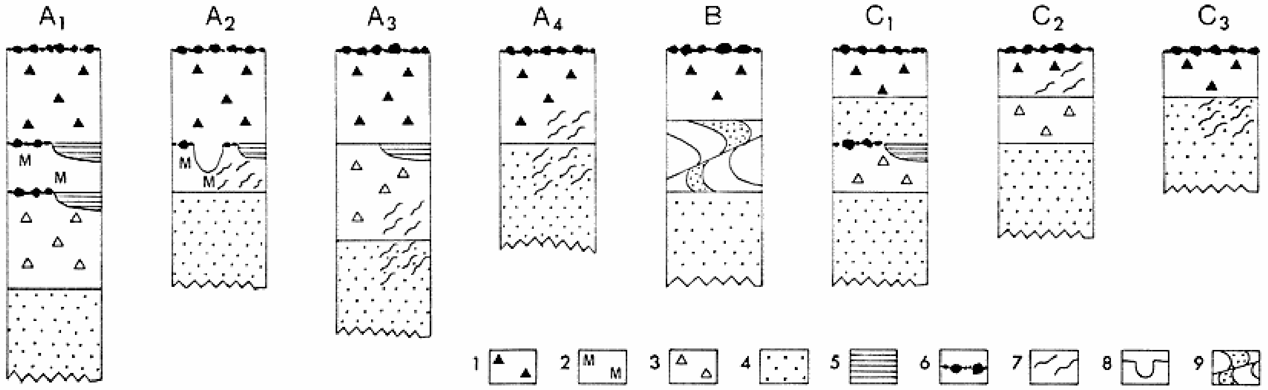

Fig. 8. Glacio-stratigraphic columns representing 75 investigated localities in the ground moraine. The A-columns represent the area between the glacier and the overridden push-moraine, column B the overridden push-moraine, and the C-columns the area between this moraine and the marginal landsystem from 1890. (1) Upper till. (2) Middle till. (3) Lower till. (4) Glaciofluvial deposits. (5) Lake deposits. (6) Clast pavement. (7) Dislocated deposits. (8) Proglacial meltwater channel cut in till. (9) Large-scale deformations. The lithological units are not drawn to scale.

raine discordantly.

On the basis of their sedimentological and structural components, the three till units are interpreted as lodgement tills (Boulton, 1978; Krüger, 1979, 1984). It seems reasonable that the included bodies of sorted sediments were detached from the substratum either by dragging (Krüger, 1979) or by recurrent proglacial thrusting, folding, and stacking during the ice advance, succeeded by overriding and subglacial shearing (Krüger, 1985a).

The following evidences in the till bed interfaces indicate the nature of the environments between deposition of the three till beds. The layer of clasts which often characterizes the interface between till beds corresponds to the clast pavement covering the surface of the present ground moraine. Consequently, these layers were deposited from the glacier sole during ice-front retreat and indicate that the under-lying till bed has been exposed as ground moraine. The occurrence of lake sediments, glaciofluvial deposits, or channel-structures between the till beds also indicates that the under-lying till bed has been exposed as ground moraine. Incomplete succession of till beds is probably due to local removal of one or two till beds by laterally-migrating proglacial meltwater streams during periods of deglaciation like the scenery in the glacier forefield at present.

The lithostratigraphic divisions of the glacier forefield are interpreted as a response to a glacier advance, a following retreat, a subsequent limited re-advance, a following retreat, and a more extensive re-advance succeeded by retreat of the glacier and exposing of the actual ground moraine. After deposition of each till unit a subglacial landsystem like the present ground moraine was exposed by frontal glacier retreat, but it was partly modified by glaciofluvial processes in the direction of a proglacial landsystem.

The marginal landsystem

The marginal landsystem is 75-150 m wide and curves

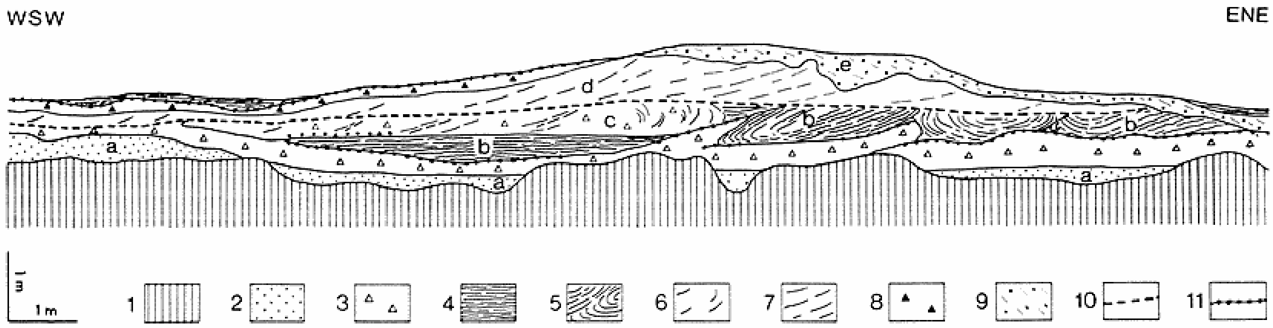

Fig. 9. Section in the innermost part of the marginal landsystem. (1) Scree. (2) Meltwater deposits. (3) Lower lodgement till. (4) Undisturbed lake deposits. (5) Dislocated lake deposits. (6) Dislocated lower lodgement till and lake deposits. (7) Dislocated till with banding and thrust planes. (8) Upper lodgement till. (9) Gravelly sediment-flow deposits. (10) Prominent shear-plane. (11) Clast pavement.

slightly following the trend of the present glacier front. It consists of push-moraine hills which form at least three well-defined parallel ridges with very uneven crests as high segments are linked together by lower sections (figures 2 and 10). The outer moraine ridge, 3-4 m high, has sharp crest, and the slope gradients are 15-25°. The inmost ridges are generally lower and more gently sloped. The moraine ridges are separated by elongated depressions, 80-100 m wide, of fluted ground moraine or flat-bottomed beds of outwash gravel joined to fan-like features beyond the marginal landsystem. Several small basins are draped with downwash deposits, lake sediments, or aeolian sand. Tongues of sediment-flow deposits extend from the foreslope of the moraine ridges onto the intervening depressions or the outwash plain in front of the moraine system. At many points glaciofluvial streams have broken the marginal moraine ridges. Some of these gaps are small and lead to depressions between the ridges or open into the outwash plain. Others appear as broad channels cut through the whole marginal landsystem. Here and there meltwater erosion has systematically stripped the marginal moraine system from the glacier forefield.

The outer moraine ridge was formed during a glacier advance where the ice pushed and folded the sediments in the frontal terrain, especially gravelly meltwater deposits from the overridden outwash fan. The internal composition of one of the innermost push-moraine ridges is shown in fig. 9. Meltwater deposits (a) are discordantly overlain by lower lodgement till which passes upwards with an abrupt change into stratified sand and silt (b) deposited in a shallow proglacial pond. In the right-hand part of the section these deposits are deformed due to marginal ridge construction by an ice push from the south. In the left-hand part the lake deposits are undisturbed and rest on the former ground surface of lower till and the backslope of the ridge suggesting that the lake deposits were accumulated after construction of the ridge. This part of the succession is overlain by drift (c and d) which is strongly deformed by an ice push from south-west. The dislocated drift is cut by a shear zone which can be traced laterally along the whole exposure. In the left-hand part of the section the succession is capped by the upper lodgement till, forming a 10-20 cm thick surface layer on the backslope of the present ridge. In the right-hand part the dislocated division is capped by sediment-flow deposits (e). This exposure represents an ice-marginal ridge superimposed on remnants of a pre-existing push-moraine ridge (Krüger, 1987b).

3-4 km west of Mælifell the marginal landsystem consists of 6 well-defined parallel ridges (see fig. 2 in Krüger and Thomsen, 1984). The innermost ones, however, appearing as very smoothed ridges with a fluted surface, are interpreted as overridden push-moraine ridges formed during the same ice advance which formed the buried push-moraine in the bottom half of the section shown in fig. 9. In the Bláfjöll area (fig. 1), the outermost ridge of the oldest push-moraine system extends 50 m beyond the youngest one. In sharp contrast with the young system the surface of the older ridge is mossgrown.

Based on these observations it is concluded that the present marginal landsystem consists of two marginal push-moraine systems which indicate the two most prominent extensions of the glacier in historical time and these ice-front positions were almost identical.

The proglacial landsystem

Beyond the marginal landsystem the outwash plain constitutes a series of fan-shaped features with many abandoned braided river channels, which indicate the changing pattern of the drainage system during the development of the plain (fig. 10). The most prominent outwash fans are connected with gaps in the marginal moraine ridges. These fans were produced by meltwater from the ice margin at the maximum extent of the glacier about 1890-1900 or during the following glacier retreat. Abandoned braided river channels cut by the outermost marginal moraine ridges suggest that parts of the plain make up remnants of an outwash fan formed prior to the formation of the push-moraine (Krüger, 1987b).

In the proximal part of the proglacial landsystem the recent principal drainage routeways are confined to distinct valleys, 2-4 m deep, 100-400 m wide, 1-2 km long. Dry-gully patterns on the surface of the adjoining outwash plain are produced by backward erosion of water from the intensive melting of snow during spring. During this time the ground surface underlying the snow is still frozen and the snow-meltwater has to flow over its surface following the fossil glaciofluvial braided stream channels (Churski, 1973; Krüger, 1985b). On reaching the gully mouth, the snow-meltwater accumulated the eroded material as a fan-like feature in the progalcial valleys. After snowy winters, however, the terraces in the valleys are reactivated because the valley floor is packed with snow. Consequently, most of the fan-like features at the mouth of the gullies are removed (Krüger, 1987b).

Further downstream, beyond the mouth of the proglacial valleys, the eroded material from the proximal part of the outwash plain and from the landscape behind the marginal moraine is redistributed and new outwash fans are being developed producing the distal part of the extensive proglacial landsystem.

THE LANDSCAPE DEVELOPMENT

At present no datings on materials from the northern margin of Mýrdalsjökull are available, but it is believed that a tephra layer embedded in the extensive body of glaciofluvial deposits underlying the till sequence originates from the development of the Eldgjá eruption fissure

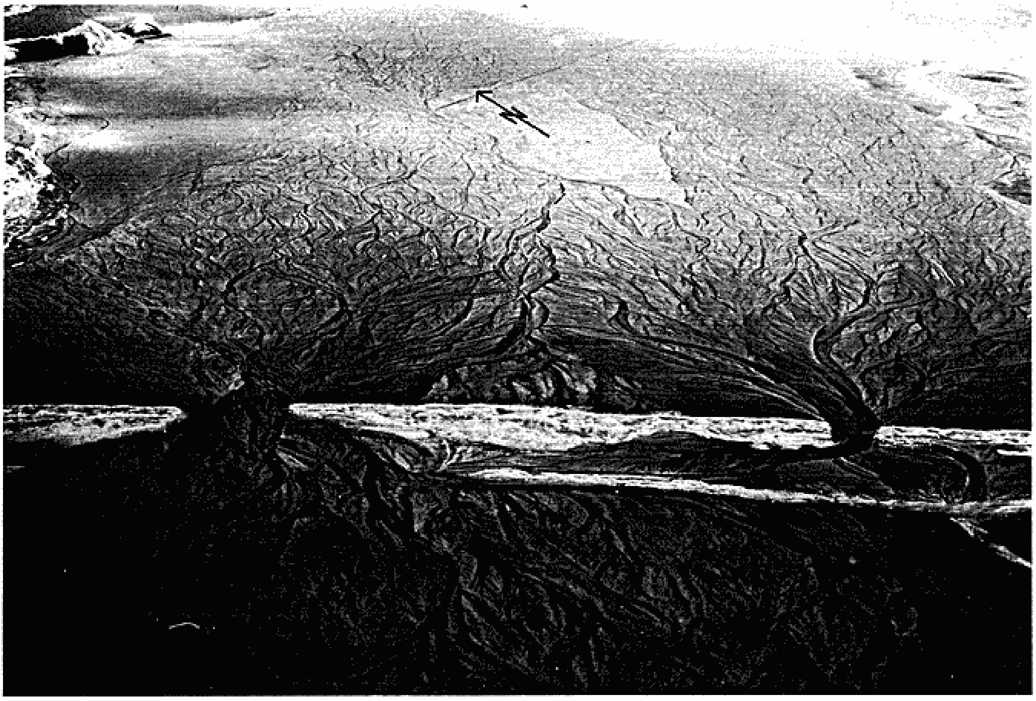

Fig. 10. Oblique photograph showing part of the proglacial and marginal landsystem south-east of Mælifell (see fig. 2). The dashed line indicates an erosion scarp separating two prominent outwash fans with abandoned braided river channels connected with gaps in the marginal moraine. Channels cut by the marginal moraine (below the dashed line) indicate that parts of the plain were formed prior to the maximum extent of the glacier. In the top right-hand corner a proglacial meltwater valley is seen. The distance between the gaps in the marginal moraine is 300 m, and the distance between the moraine and the basalt hills seen in the top left-hand corner is about 1.5 km. August 1984.

which dates back some 1000-1200 years (Thorarinsson, 1955). This suggests that parts of the glaciofluvial division date back to the Landnam phase and the early Middle Ages. At that time the climate was similar to that of the warm period from 1920 to 1960 (Björnsson, 1979) and the ice cap was smaller than it is today. Meltwater crossing the proglacial area probably stripped all morainic landforms from the glacier forefield along the northern margin of the ice cap, and as a consequence the following landscape development started from a mature proglacial landsystem. It is tentatively proposed that the superjacent till sequence results from glacier fluctuations within the historically recent past where the Little Ice Age, dated in a general way to 1600-1920, represents the coldest period (Bergthorsson, 1969). During the Little Ice Age the local maxima of glacier advance in Iceland grouped around 1750 or 1850-94 (Thorarinsson, 1943).

The lower till bed and the base of the marginal landsystem about 1.5 km beyond the present ice edge are interpreted as responses to a glacier advance about the middle of the 18th century (A in fig. 11). The middle till as well as the overridden marginal landsystem 0.6-0.8 km in front of the glacier originate from a subsequent limited re-advance (C in fig. 11) while the upper till and the youngest elements of the marginal landsystem date back to a more extensive re-advance about 1890 (E in fig. 11). In 1906 the ice edge was only 50-140 m behind the most out-lying push-moraine ridges (Sapper, 1909). During the following retreat of the glacier the present ground moraine was exposed.

During periods of deglaciation (B, D, and F in fig. 11) the marginal landsystem and the exposed subglacial landsystem become more or less dissected by a branching network of meltwater streams. The laterally migrating streams disintegrated parts of the ground moraine and formed broad channels and outwash fans with intervening plateaux of resistant ground moraine. This transformation of the subglacial landsystem in the direction of a proglacial landsystem, however, was interrupted by subsequent flows of ice across the area. The most prominent terrain elements in the pre-existing landscape offered favourable conditions for development of undulating ground moraine, or acted as subglacial obstacles, leading to localized till deposition and drumlin formation. Pre-existing outwash fans or extensive till plains favoured formation of a new till plain.

At present the ice front position is stationary, or slightly advancing (fig. 12), probably as a response to a general climatic deterioration in Iceland since the 1960s (Schunke, 1979; Liebricht, 1983). The average annual

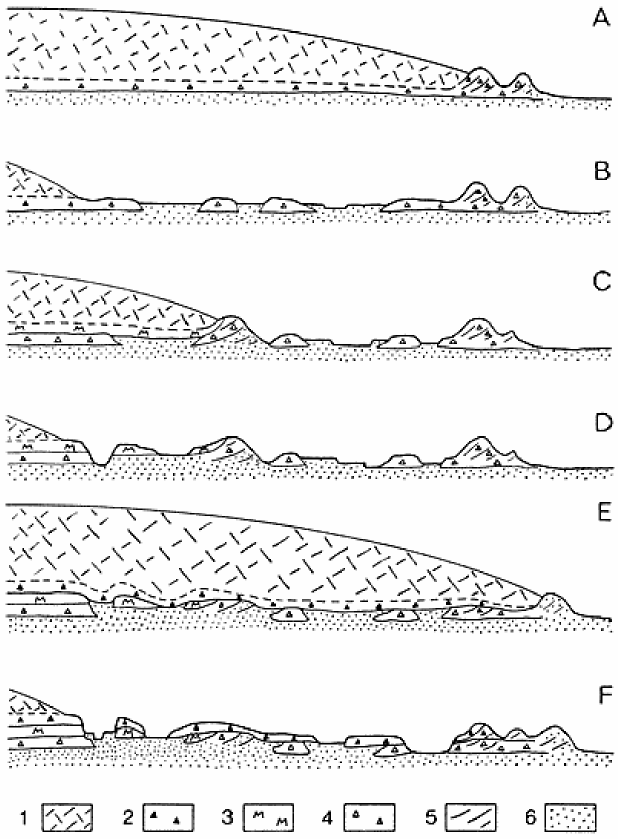

Fig. 11. Simplified sequential model for glacial landscape formation at the northern margin of Mýrdalsjökull. (A) Around 1750. (B) At the end of the 18th century. (C) At the beginning of the 19th century. (D) In the middle of the 19th century. (E) About 1890. (F) Present situation. (1) Glacier. (2) Upper lodgement till. (3) Middle lodgement till. (4) Lower lodgement till. (5) Dislocations. (6) Meltwater deposits. (After Krüger 1987b)

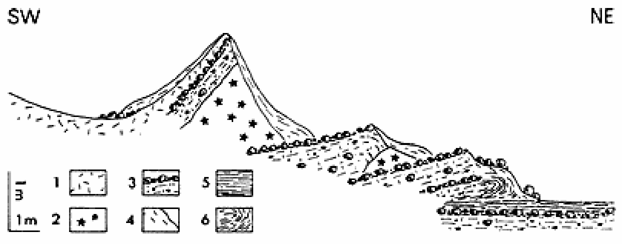

Fig. 12. Push moraine under formation along the slowly advancing ice front at the northern margin of Mýrdalsjökull in 1986. The glacier advances over ground moraine consisting of the upper lodgement till. In front of the glacier the ground moraine is mantled by lake deposits in small depressions. (1) Glacier ice. (2) Snow and firn. (3) Slab of upper till mantled by a clast pavement. (4) Sediment-flow deposits. (5) Undisturbed lake deposits. (6) Dislocated lake deposits.

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CONCLUSION

On the basis of glacial-morphological and sedimentological investigations in the northern forefield of Mýrdalsjökull, Iceland, the following conclusions are proposed:

1. The actual glacier forefield consists of three landsystems which reflect the large-scale depositional environments: An ice-marginal landsystem of push-moraine ridges separates a proglacial landsystem of extensive outwash fans from a subglacial landsystem of fluted and partly drumlinized ground moraine.
2. The lithostratigraphic divisions of the glacier forefield are tentatively interpreted as responses to a glacier advance about the middle of the 18th century, a following retreat, a subsequent limited re-advance, a following retreat, and a more extensive re-advance about 1890; the latter has been succeeded by a continuous retreat in the present century. Most recently the glacier is re-advancing.
3. During periods of deglaciation the marginal and the exposed subglacial landsystem were modified by glaciofluvial processes in the direction of a proglacial landsystem, but subsequent flows of ice across the area have led to deposition of lodgement tills and renewal of the subglacial landsystem.
4. The actual landscape is a superimposed pattern of landforms derived from different development phases and glacial events.

It is believed that studies of superimposed patterns of landforms from modern multiple glaciations are of exceptional interest to students of the Pleistocene glaciations in the lowlands across northern Europe and North America.

ACKNOWLEDGMENTS

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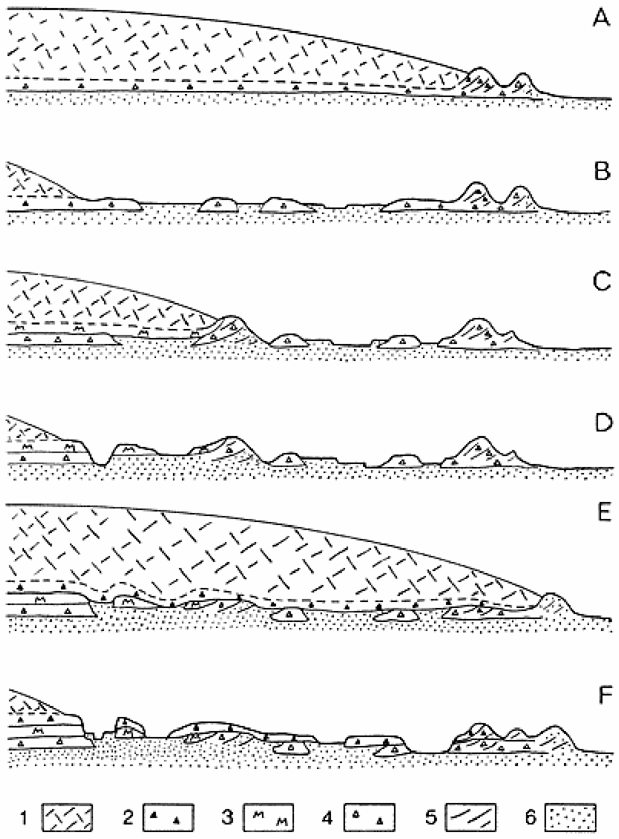
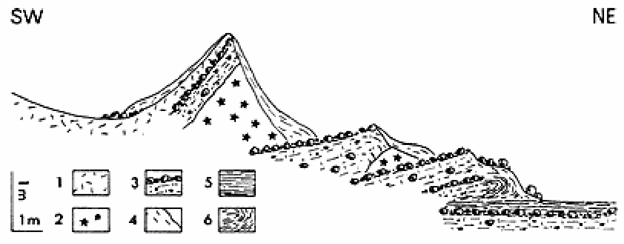


Fig. 11. Simplified sequential model for glacial landscape formation at the northern margin of Mýrdalsjökull. (A) Around 1750. (B) At the end of the 18th century. (C) At the beginning of the 19th century. (D) In the middle of the 19th century. (E) About 1890. (F) Present situation. (1) Glacier. (2) Upper lodgement till. (3) Middle lodgement till. (4) Lower lodgement till. (5) Dislocations. (6) Meltwater deposits. (After Krüger 1987b)



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